REMARKS

Status of Claims:

Claims 1-12 were originally filed with the patent application. Claim 11 is being canceled by this Amendment and Response. Claims 13-23 are being added by this Amendment and Response. Therefore, Claims 1-10 and 12-23 will be pending upon entry of this Amendment and Response.

Information Disclosure Statement:

The Examiner raised an issue with regard to the citation of patents in the body the above-captioned patent application. Enclosed is a Supplemental Information Disclosure Statement that identifies the various patents identified in the body of the above-captioned patent application.

Drawing Objections:

The Examiner objected to the drawings in relation to the type of features presented in Claim 6. Applicant refers the Examiner to the embodiment of Figures 6D-E of the above-captioned patent application, that support the subject matter of Claim 6. Figures 6D-E are discussed on page 51, lines 4-22 of the above-captioned patent application.

Specification Objections:

The Examiner has objected to the specification for not including the current status of the parent application. The above-noted amendment of the relevant section of the patent application inserts the current status of the parent application.

The Examiner also requested that a more descriptive title be used. The above-noted amendment of the title is offered for consideration by the Examiner.

§112 Rejections:

Claim 6 stands rejected under 35 U.S.C. §112, first paragraph, for failure to comply with the written description requirement. Applicant refers the Examiner to Figures 6D-E and to the corresponding discussion on page 51, lines 4-22 of the above-captioned patent application.

Claim 6 stands rejected under 35 U.S.C. §112, second paragraph, for "omitting essential structural cooperative relationships of elements", namely for what the Examiner considers to be a "gap" between the lever microstructure and elongate coupling microstructure. Claim 6, through its dependency upon Claim 1, requires that the lever microstructure be interconnected with the elongate coupling microstructure. Figures 6D-E again present an example where "the motion of the free end 320 of the lever 316 is not within a reference plane 334 that is at least generally perpendicular to the substrate 304" (page 51, lines 4-6 of the above-captioned patent application).

Office Action References:

The primary reference relied upon by the Examiner is JP 06-160,750 (hereafter "Japanese Document"). A translation of this document was obtained from the Japanese Patent Office Website, and is enclosed in Appendix A for the Examiner's convenience.

Independent Claim 1:

Claim 1 stands rejected under 35 U.S.C. §102(b) based upon the Japanese Document. Applicant respectfully requests reconsideration since the entire combination of features presented by Claim 1 are not disclosed by the Japanese Document. For instance, the Japanese Document does not disclose the structural arrangement presented by Claim 1 and thereby the specified manner of

operation. The Japanese Document does not disclose a mirror microstructure that is spaced from a lever microstructure and that is interconnected with a portion of a lever microstructure that is movable relative to a substrate, in combination with an elongate coupling microstructure that is located between and that structurally interconnects this lever microstructure with an actuator assembly microstructure that moves relative to the substrate, all as required by Claim 1. Claim 1 of course presents other limitations, including that the movement of the first lever end of the lever microstructure be "at least substantially solely controlled by external forces that are exerted on said elongate coupling microstructure during said accelerating step" (e.g., by being a "stiff" coupling), in contrast to that disclosed at page 3, lines 13-15 of the above-captioned patent application.

In accordance with the enclosed translation of the Japanese Document, it discloses having driven sections 14, 15 between a support plate 16 and a movable electrode 12, with the driven section 14 having a reflecting plate 31 mounted directly thereon. Therefore, in the event that the Examiner takes the position that the movable electrode 12 corresponds with the actuator assembly microstructure of Claim 1 and that the driven section 15 corresponds with the elongate coupling microstructure of Claim 1,the Japanese Document would not disclose a lever microstructure that is interconnected with an elongate coupling microstructure and that further is interconnected with a mirror that is spaced from the lever microstructure.

Based upon the foregoing, Claim 1 is allowable over the Japanese Document. Claims 2-10 and 12, which depend from Claim 1, are thereby also allowable over the Japanese Document. There is therefore no need to separately address the patentability of each of these claims and/or the Examiner's interpretation in relation to any of these claims or any of the references of record in relation thereto.

New Independent Claim 13:

The Japanese Document also fails to disclose the entire combination of features presented by new independent Claim 13. For instance, the Japanese Document does not disclose moving an actuator assembly microstructure, that in turn pulls on an elongate coupling microstructure, that in turn increases in spacing between a first lever end of a lever microstructure and a substrate, and that in turn increases a spacing between a mirror microstructure and the substrate, all as required by Claim 13. The Japanese Document further does not disclose moving an actuator assembly microstructure, that in turn pushes on the elongate coupling microstructure, that in turn decreases the spacing between the first lever end of the lever microstructure and the substrate, and that in turn decreases a spacing between the mirror microstructure and the substrate, all as required by Claim 13. Claim 13 of course presents other limitations, including that the movement of the first lever end of the lever microstructure that decreases a spacing between the first lever end of the lever microstructure and the substrate be "at least substantially solely controlled by external forces that are exerted on said elongate coupling microstructure during said accelerating step" (e.g., by being a "stiff" coupling), in contrast to that disclosed at page 3, lines 13-15 of the above-captioned patent application.

In accordance with the enclosed translation of the Japanese Document, it discloses having driven sections 14, 15 between a support plate 16 and a movable electrode 12, with the driven section 14 having a reflecting plate 31 mounted directly thereon. In the event that the Examiner takes the position that the driven section 15 corresponds with the elongate microstructure of Claim 13, the Japanese Document suffers from a number of deficiencies. One would be that having the movable electrode 12 pull on the driven section 15 would actually reduce the spacing between the driven section 14 and any underlying substrate, in direct contrast to the requirements of Claim 13.

Another would be that having the movable electrode 12 push on the driven section 15 would actually increase the spacing between the driven section 14 and any underlying substrate, in direct contrast to the requirements of Claim 13.

Based upon the foregoing, Claim 13 is allowable over the Japanese Document. Claims 14-23, which depend from Claim 13, are thereby also allowable over the Japanese Document.

Conclusion:

Based upon the foregoing, Applicant believes that all pending claims are in condition for allowance and such disposition is respectfully requested. In the event that a telephone conversation would further prosecution and/or expedite allowance, the Examiner is invited to contact the undersigned.

Respectfully submitted,

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Appendix A

(JPTO Translation of JP 06-160,750)

* NOTICES *

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the optical deflector using very small actuator and this. moreover, this invention -- electrostatic force -- using -- a light beam -- ****** -- it is related with the light-scanning equipment in which things are possible.
[0002]
[Description of the Prior Art] Conventionally, there is a mechanical thing using the thing of the acoustooptics type using distortion by the supersonic wave of a crystal, the thing using the refractive-index change by the electric field of a crystal of an electric type or an oscillating plane mirror (the so-called galvanomirror), a rotation polyhedron (the so-called polygon mirror), etc. in the optical deflector and light-scanning equipment which are mainly used. Especially, since it is not based on the wavelength of light but an equiangular deviation can be performed, a mechanical optical deflector becomes very useful, when making the source of multiple wave Nagamitsu into the use light source, or when there is wavelength variation etc. In order to acquire a stable rotational speed and the stable highly precise deflection angle, these make a revolving shaft heavy or use the large-sized electromagnet for Rota.
[0003] On the other hand, producing a very small actuator is examined using the photolithography technique. As a typical minute machine Micro motor (M.) [Mehregany] et al. and "Operation of microfabricated harmonic and ordinary side-drive motors" and Proceedings IEEE Micro Electro Mechanical Systems Workshop 1990p1-8, On monotonous, according to electrostatic force The linear micro-actuator of the comb mold structure to drive (W.) [Tang et al., "Laterally driven polysilicon resonant microstructures",] [Sensors] and Actuators 20 (1989)p25-32 etc. is devised. If these minute machines are used, array-izing and low-cost-izing will be easy, and highly precise-ization of them will be attained.
[0004] The space optical deflector (Larry Jay Horn Beck, JP,2-8812,A) which is partly proposed also as a mechanical optical element, among these took into consideration improvement in optical effectiveness and deflection stability by the object for doubly-supported beams as an optical deflector is known.
[0005] Drawing 18 is the 1-pixel perspective view of this space optical deflector made into the cross section in part. In drawing 18 , the pixel has the composition of having a reflector by two beams in which a deflection is possible, by using monolithic silicon as the base. That is, the laminating of the insulating spacer 94, the metal hinge layer 95, and metal **** 96 is carried out through the insulating layer 93 on the silicon substrate 91. that is, the fixed electrode 99 for a drive for changing the include angle of a reflector 98 into the bottom of the reflector 98 of the flexible beam 97 and the flexible beam 971 of the metal hinge layer 95 and this layer, and a metal **** 96 and this layer, and a reflector 98 through an opening, a fixed electrode 991, and a fixed electrode 992 from -- it changes. For example, fixed electrode 991 When an electrical potential difference is impressed, they are a reflector 98 and a fixed electrode 991. Electrostatic force occurs in between and it is the flexible beam 97,971. It touches and angle of deflection arises, and the light which carried out incidence to the reflector 98 acquires the angle of reflection according to the amount of angle of deflection, and is deflected. Such an optical deflector is a configuration which deflects light only on the shaft of one direction, and can be manufactured according to the silicon process which used the silicon substrate 92 as the base. Therefore, it can manufacture to low cost comparatively and applying to printers, such as electrostatic printing, the

display of a projection mold, etc. is also considered by carrying out two-dimensional arrangement and array-izing on a silicon substrate 92.

[0006] Drawing 19 is the schematic diagram showing the configuration of conventional light-scanning equipment. In drawing 19 , the light emitted by the laser light source 803 is scanned with the oscillating plane mirror 801. And the light from the oscillating plane mirror 801 is condensed with a lens 804, the luminescent spot moves in the direction of an illustration arrow head on a screen 805, and a scan is performed.

[0007]

[Problem(s) to be Solved by the Invention] With the structure of the conventional optical deflector, since the part which receives the force, and the part which reflects light are the same locations, it is easy to receive the force of disturbance, such as rotation. Since the part and reflector which receive the force similarly are the same, precision control of an include angle is difficult. Moreover, a degree of freedom does not have the direction of incidence, and the reflective direction at immobilization. Furthermore, since the reflector has become some movable metal electrodes, there is a possibility that a deflection angle may change by aging, such as metal fatigue by torsion or the operating environment.

[0008] Similarly, with conventional light-scanning equipment, since the dimension of an oscillating plane mirror or a rotating polygon is comparatively large, there is a fault that equipment will be enlarged. Moreover, the optical adjustment at the time of having to arrange each component by strict physical relationship, in order to perform an exact scan, and finishing setting-up equipment is very complicated.

[0009] The purpose of this invention is to offer a new micro-actuator and offer the optical deflector with precise controllable high dependability of an include angle using a micro motor or a linear micro-actuator, in order to solve an above-mentioned trouble.

[0010] Other purposes of this invention are canceling the fault of the above-mentioned conventional example and offering light-scanning equipment with easy optical adjustment with a compact configuration.

[0011]

[Means for Solving the Problem] The mechanical component which the micro-actuator of this invention becomes from a fixed electrode and a movable electrode, At least two driven sections to which the end was connected at the joint by which fixed support was carried out, It is the micro-actuator with which it has the joint which connects said mechanical component and said driven section, and said driven section carries out bending actuation repeatedly in the part of said joint. Said mechanical component drives said driven section according to the electrostatic force generated by impressing an electrical potential difference between said fixed electrodes and said movable electrodes, and said driven section is characterized by being that from which the direction of the force generated in said mechanical component and the direction of the variation rate of the driven section concerned differ.

[0012] There are some by which said mechanical component and the driven section are accumulated into the same substrate in the micro-actuator of this invention.

[0013] There are some whose direction of the force which the direction of the force generated in said mechanical component generates in a substrate side in what is parallel displacement, and said mechanical component is the direction of the substrate side internal version in the micro-actuator of this invention.

[0014] What grows into said joint with a metal thin film, the thing which changes by the poly membrane, There are what changes with a ceramic thin film, and a thing which changes with a superelastic thin film.

[0015] The optical deflector of this invention has the micro-actuator of this invention, equips at least one place of the driven section of this micro-actuator with a reflector, and is characterized by making the light which irradiated this reflector scan.

[0016] There are what changes by the metal membrane, a thing which changes with the metal vacuum evaporationo film, a thing which changes with the metal plating film, a thing which changes with a single crystal metal thin film, and a changing-with liquid phase epitaxy single crystal metal thin film thing in said reflector.

[0017] The light-scanning equipment of this invention has the 1st electric conduction field which has optical waveguide and conductivity in the cantilever of a thin film configuration. The 2nd electric

conduction field which has an insulating region in said cantilever near [said] the waveguide, and has conductivity across this insulating region is arranged. According to the electrostatic force produced between the 1st electric conduction field in said cantilever, and the 2nd electric conduction field, and the elastic force which said cantilever restores from deformation By moving the cantilever of a thin film configuration in accordance with the configuration of structure including the 2nd electric conduction field, it is characterized by moving the light beam introduced into the optical waveguide arranged in said cantilever from the light source arranged at the root of said cantilever.

[0018] It has two structures including said 2nd electric conduction field to the light-scanning equipment of this invention, and there are some against which these stand face to face on both sides of said cantilever in it.

[0019] There are what the electrostatic force produced between the 1st electric conduction field in said cantilever and the 2nd electric conduction field commits effectively gradually from the part of the root of this cantilever, a thing to produce by applying an electrical potential difference to two electrodes, and a thing which applies an electrical potential difference to the 2nd electric conduction field in the light-scanning equipment of this invention.

[0020] Said the 1st some or all of an electric conduction field is able to consist of a semiconductor material with the light-scanning equipment of this invention.

[0021]

[Function] The optical deflector of an above-mentioned configuration is the configuration that a reflector is separated, and it is decided uniquely that the displacement direction of a reflector will be the part which receives the force of a drive by connecting a fixed electrode, a movable electrode, and moving part-ed using joint, and the direction of incidence and the direction of outgoing radiation can be chosen freely, drives the driven section which has established the reflector and performs an optical deflection according to the electrostatic force generated by impressing an electrical potential difference between a fixed electrode and a movable electrode.

[0022] Moreover, the actuator produced using a thin film material and structure is applied to the actuator used in the light-scanning equipment of this invention. Generally, as a gestalt of an actuator, various gestalten, such as a cantilever (cantilever), a doubly-supported beam, a membrane, a hinge, and a motor, can be considered. There are what uses a volume change as the drive approach of each actuator by the electrostatic drive using the bimorph using the piezo-electric effect, a uni-morph, and a confrontation electrode, the bimetal and the shape memory alloy using heat, electric field, etc., a thing to displace with a gaseous pressure. The electrostatic drive which used the confrontation electrode especially is advantageous at the point which seldom needs the force, when carrying out the variation rate of the optical waveguide of the cantilever mold of a thin film configuration, deflecting light and using.

[0023]

[Example] Next, the example of this invention is explained with reference to a drawing.

[0024] Drawing 1 is a perspective view showing the actuator 10 of the 1st example of this invention. A fixed electrode 11, a support plate 16, and supporting beam 13,131 It is fixed on the same substrate (un-illustrating) which consists of Si. A movable electrode 12, the driven sections 14 and 15, and a support plate 16 are connected through joint 19, 18, and 17.

[0025] The fixed electrode 11 and movable electrode 12 of this example were made into the linear micro-actuator of the above-mentioned comb mold produced by the micro mechanics technique.

[0026] Actuation of the actuator 10 of this example is explained using drawing 2 . By impressing an electrical potential difference between a fixed electrode and a movable electrode 12, a movable electrode 12 carries out parallel actuation to a substrate at parallel repeatedly with electrostatic attraction (the direction of drawing 2 (a) arrow-head B). In connection with this, the driven sections 14 and 15 also perform bending actuation repeatedly in a joint part (the direction of drawing 2 (b) arrow-head C), and convert the force generated in parallel with a substrate in the direction perpendicular to a substrate.

[0027] Drawing 3 is the perspective view of the optical deflector 86 which used the actuator 10 of the 1st example of this invention. The driven section 14 of the actuator 10 shown in drawing 1 is equipped with the reflecting plate 31. It has the composition that the include angle of the driven section 14 changes by the difference in the variation rate of the movable electrode 12 by applied voltage, and the outgoing radiation light 33 is scanned in the range of the scan include angle theta, to incident light 32.

[0028] Thus, since the mechanical component and the reflector are separated, the direction which

receives the force of a reflector determines the constituted optical deflector 86 uniquely, and it does not receive the disturbance effectiveness, such as rotation. Moreover, precision control of an include angle also becomes easy for the same reason. Furthermore, since joint has not contributed to the include-angle control by electrical-potential-difference impression, joint material can be chosen freely and insulating materials, such as a poly membrane the spring constant excelled [poly membrane] in endurance sufficiently small, can be used.

[0029] Next, abbreviation explanation of the one example of the actuator of this invention and the production process of an optical deflector is given using drawing 4 . Drawing 4 is the A-A line sectional view of drawing 1 . After carrying out the ion implantation of Lynn to the substrate 41 which consists of silicon, 5000A of thermal oxidation film 42 is formed as an insulating layer, and 1500A of silicon nitrides 43 is further produced with reduced pressure CVD (LPCVD) on this. A contact hole 44 is patterning-formed by making a part of this insulating layer into a photolithography by etching (drawing 4 (a)). Although etching performed dry etching, using CF4 as reactant gas, the wet etching by buffer fluoric acid etc. is sufficient. Subsequently, after producing the 3000A of the 1st phosphorus doping polysilicon contest layers by LPCVD, the electric shielding section 45 was formed by patterning (drawing 4 (b)). However, Lynn may be poured in with ion-implantation after polish recon formation. Sacrifice layer silicon oxide 46 is produced by the vacuum sputtering method, and formation (drawing 4 (c)) and after carrying out patterning, 2 micrometers of phosphorus doping polysilicon contest film 47 are produced by LPCVD. It cannot be overemphasized that Lynn may be poured in with ion-implantation. Patterning of the phosphorus doping polysilicon contest film 47 is carried out, and a fixed electrode, a mechanical component, the driven section, a support plate, and joint are formed (drawing 4 (d)). Of course, although polish recon was used as joint here, as long as a load rate is sufficiently small, other metal membranes may be formed or a poly membrane may be formed. The micro-actuator 10 shown in drawing 1 by removing sacrifice layer silicon oxide with a fluoric acid water solution is formed (drawing 4 (e)). Moreover, before removing a sacrifice layer, the optical deflector 86 shown in drawing 3 is produced by forming and carrying out patterning of the metal vacuum evaporationo film 48 to a part of driven section, and forming a reflector (drawing 4 (f)).

[0030] Thus, the micro-actuator and optical deflector which were produced can also be array-ized further small and lightweight. When considered as die length of 50 micrometers of gap 2micrometer of several 11 comb of the comb of a die-length Kushigata fixed electrode of 200 micrometers of the beam with which the movable electrode was equipped, and the driven section, the variation rate of 0.1 micrometer/V was obtained. That is, the variation rate of 4 micrometers was obtained by applied-voltage 40V, and the variation rate of about 20 micrometers has been attained perpendicularly. In the optical deflector furthermore produced using this actuator, the scan with a scan include angle of theta= 90 degrees - 44 degrees was attained in the direction shown in drawing 3 .

[0031] Here, although Si substrate was used, the approach of joining the structures, such as a mechanical component and a fixed electrode, may be used on a glass substrate.

[0032] Drawing 5 is a perspective view showing the actuator of the 2nd example of this invention. For a movable electrode 52, the driven sections 53 and 54, and the fixed support plate 55, it connects with joint 58, 57, and 56, and a movable electrode 52 is a supporting beam 59,591. It supports. A fixed electrode 51 is the same as the fixed electrode 11 of drawing 1 . The fixed electrode and the movable electrode were made into the linear actuator which used the micro mechanics technique like [the actuator of this example] the actuator of the 1st example.

[0033] The production approach is the same as that of the 1st actuator. Drawing 6 is drawing explaining actuation of the actuator of this example. A movable electrode 52 carries out a variation rate to a substrate (un-illustrating) in parallel by impressing an electrical potential difference to the fixed electrode 51 and movable electrode 52 which are shown in drawing 5 (the direction of drawing 6 (a) arrow-head D). It enabled them for the driven sections 14 and 15 to also receive the force and to displace it by this, in the direction (the direction of drawing 6 (b) arrow-head E) perpendicular to a substrate, parallel, and the displacement direction of a movable electrode 12.

[0034] Moreover, if a reflecting plate is formed in the driven part of this actuator, an optical deflector will be obtained like the 1st actuator.

[0035] Drawing 7 is a perspective view showing the actuator of the 3rd example of this invention. A movable electrode 72 and the driven sections 74 and 75 are connected at joint 79, 78, and 77. The

movable electrode 72 which rotates at a level with the direction of arrow-head F consists of Rota of an eight-sheet spring. It is projection 721 to the end of this movable electrode 72. It is formed and is projection 721. It is formed in the driven section 73 and is a slit 731. It is engaged. Thereby, if a movable electrode 72 rotates in the direction of arrow-head F, the driven section 73 will be driven in the direction of arrow-head G, and the joint 78 which connects the driven sections 74 and 75 will carry out both-way migration in the direction of arrow-head H. The driving means shown here was made into the above-mentioned micro motor.
[0036] The actuator of this example performs the motion as the 1st actuator with the same driven section with rotation of a micro motor. By this configuration, substrate side internal-version driving force is changed into a variation rate perpendicular to a substrate.
[0037] As the production approach of the actuator of this example, using the technique which forms the micro motor of a micro mechanics technique, it sets like a micro-motor formation fault, and the driven section was made to coincidence, and further, joint was made like the first example and formed the lump actuator.
[0038] Moreover, although the rotor uses the micro motor of an eight-sheet spring, the micro motor of a four-sheet spring, a six-sheet spring or a multiple column, and a cylinder is sufficient here. Moreover, it is not analog-like, and when driving for digital one, it cannot be overemphasized that a micro stepping motor may be used.
[0039] Thus, by making the produced actuator into die length of 80 micrometers of the rotation section radius of 100 micrometers, 1.5 micrometers of openings, and moving part-ed, and being impressed by each fixed electrode 70V, rotation was begun and, as for the movable mechanical component, 80-micrometer repeat round trip actuation was attained in parallel. In connection with this, the driven section also received the force and attained the variation rate of 80 micrometers in the direction perpendicular to a substrate. Moreover, as for the optical deflector produced using this 3rd actuator, the theta= 87 degrees - -90 degrees scan was attained.
[0040] Drawing 8 is a perspective view showing the actuator of the 4th example of this invention. A movable electrode 81, the driven sections 82, 83, and 84, and the fixed support plate 85 are connected by joint 78, 77, and 76. The driving means was made into the micro motor which used the micro mechanics technique like [the actuator of this example] the 3rd actuator.
[0041] Actuation of the actuator of this example performs the motion as the 2nd actuator with the almost same moving part with rotation of a micro motor. By this configuration, a variation rate is changed in the direction [parallel to the rotation driving force substrate side within a substrate side and] perpendicular to a drive plate.
[0042] The production approach as well as the 2nd and 3rd actuator was produced.
[0043] In addition, it is two or the actuator 101 beyond it, and 102 like drawing 9 . It can make together.
[0044] An optical deflector 86 can be used as a laser beam scanner which carries out like drawing 10 and carries out rapid scanning of 1-dimensional Rhine. Otherwise, it is possible to use for application, such as an optical switch and an optical scanner, in consideration of the drive approach and the direction of outgoing radiation.
[0045] as mentioned above, the example of the actuator of this invention -- among these, although the example of the optical deflector using some actuators was explained, it cannot be overemphasized that the optical deflector using which actuator also has the same effectiveness. According to the purpose of use, the configuration of an actuator can be chosen and the direction of the outgoing radiation light to incident light can also be chosen. Moreover, although what equipped a part of driven section of the next door of a fixed support plate with the reflecting plate was shown here, the optical deflector equipped with the reflecting plate all over other driven sections or the driven section is sufficient.
[0046] Hereafter, in the example of an embodiment (drawing 11), the basic configuration of the light-scanning equipment of this invention is explained.
[0047] The basic configuration of the actuator used in the example of an embodiment shown in drawing 11 sandwiches insulating layer 101a, and the structure which is the electrostatic-capacity structure of having two conductive fields 102a and 103a is applied. One conductive field 103a is incorporated in the cantilever 105 of a thin film configuration together with optical waveguide 104. Optical waveguides 104 may be all membranous fields, or may be partial. The conductive field 102 touches a cantilever 105 by root Motobe 106a of one side, and has the aspect-of-affairs structure which is so thin that it goes

previously. Although what kind of configuration is [that the aspect of affairs of the tangent of aspect-of-affairs structure should just correspond with the field of a cantilever 105 continuously about the inclination configuration to a tip] sufficient as long as it is configuration continuation of an aspect of affairs, what is necessary is just radii, a part of ellipse, a parabola, and a hyperbola preferably. As this invention is shown in drawing 11 , it is desirable to already carry out lot arrangement of the conductive field. That is, on both sides of insulating-layer 101b, conductive field 102b is prepared in the opposite side of conductive field 103b of ****** 2, conductive field 102a, and a beam 105. The variation rate of a beam can be symmetrically produced to a beam by this. However, function sufficient by just carrying out lot arrangement of the conductive field can be generated. The light by which outgoing radiation was carried out from the non-illustrated light source is introduced into optical waveguide 104, progresses in the direction of an illustration arrow head (from the left to the right), and carries out outgoing radiation from optical waveguide 104 tip.

[0048] The actuator used for the example of an embodiment of drawing 11 produces an electrostatic suction force strong against root 106a of a cantilever 105 first by impressing an electrical potential difference to conductive field 102a and conductive field 103a. Therefore, since the opening of the conductive fields 102a and 103a becomes narrow and a beam 104 approaches a conductive field gradually, it touches so that the point of a beam may finally become being the same as that of the aspect-of-affairs configuration of an electric conduction field. In this case, it may not necessarily become the same on the balance of the rigidity of a beam, and an aspect-of-affairs configuration. Next, if applied voltage is removed, a beam will return to the original location according to the rigidity. If an electrical potential difference is shortly impressed to the conductive fields 102b and 103b when it returns to the original location, an electrostatic suction force will work again, and it moves so that the conductive fields 103b and 102b may pay well and the point of an acquaintance beam may approach 102b gradually shortly. The time of a beam coming in the center is sufficient as the timing of electrical-potential-difference impression and a change, and it can be impressed according to a motion of a beam and can build a smooth motion also with the condition of having shifted. The class of electrical potential difference to impress is chosen from a direct current, an alternating current, a pulse, etc. An electrical potential difference and its class are chosen so that the motion may turn into movement toward hope according to the configuration of a field where it is finally projected on light. Although the conductive fields 103a and 103b in a beam are made into another thing by arrangement of the symmetry in the example of an embodiment of drawing 11 , it is unsymmetrical, are superimposed on the conductive field, namely, the number of conductive fields may be one. Anything that is called usual metallic material is used as an ingredient which constitutes the conductive field used for the light-scanning equipment of this invention. For example, they are aluminum, iron, SUS, copper, brass, gold, nickel, a tungsten, chromium, etc. Moreover, it is possible to also use a semi-conductor. For example, regardless of a single crystal and a non-single crystal, they are Si, GaAs, ZnSe, etc. Moreover, the conductor of an oxide is also usable. for example, ITO, SnO_2, and ZnO_2 etc. -- it is .

[0049] As an ingredient which constitutes the insulating field used for the light-scanning equipment of this invention, SiO_2, $Si_3 N_4$, SiO_x, $SiON_x$, Si:N:H, glass, etc. are used, for example. the approach of miniaturizing and assembling the components used from the former about the process which produces the structure of the light-scanning equipment of this invention from Miri to the order of a micrometer -- the process technique of a semi-conductor and thin film deposition / etching technique are used preferably. Moreover, in order to form deep structure in the direction of thickness, it is also possible to use the lithography which used the X-ray.

[0050] As the light source arranged in contact with the above-mentioned actuator in the light-scanning equipment of this invention, light emitting devices, such as light emitting diode and semiconductor laser, an electron ray, the source of the white light, etc. can be considered. Practicality of semiconductor laser, such as application to measurement of a laser beam printer, interference measurement, etc., is large especially. As luminous efficiency and structure of the good semiconductor laser of the temperature characteristic, there are some which adopted multiplex quantum well structure. Since the laser beam emitted from semiconductor laser is generally diffused, it needs to be condensed, but in order to condense the light of the semiconductor laser produced near [minute] the cantilever like especially this invention, a minute collimator lens is required. There is an object using the photolithography technique as an example of production of such a micro collimator lens ("Fabrication of activeIntegrated Optical

Micro-Encoder" 1991 IEEE Micro Electro Mechanical Systems Workshop, Proceedings pp 233-238).
[0051] As an ingredient of the optical waveguide of this invention, a transparent dielectric layer is used to the light which carries out a guided wave, for example, glass, a quartz, SiO2, SiOx, SiOx Ny, Si3 N4, Si:N:H, ZnS, ZnO, etc. are used. It is possible by giving change of a refractive index to an ingredient along with the direction of thickness and field inboard in waveguide to diffusion of the light in optical waveguide to shut up light and to make it condense. On one substrate, the light source and an actuator may form in one and may lead even an actuator using an optical fiber etc. from the external light source.
[0052] In this invention, the light which formed the micro collimator lens in the point of the above-mentioned beam, and came out of the optical waveguide in a beam changes the magnitude of the optical spot on a screen condensing and by making it parallel, or distance with a screen can be made small. After the production approach of a lens produces a beam, the approach of pasting up a lens is sufficient as it, and in case it forms optical waveguide preferably, it is produced using the same ingredient. A cross section is chosen from a semicircle, a half-ellipse, a half-ellipse, etc., and the configuration of a lens may prepare a focal distance controller between the beam at the tip of a beam, and a lens.
[0053] If it is the member which puts and supports a component in the upper part as a base which forms a component including the components attached to these actuators, the light source, and it etc., it is good, for example, anything is chosen from conductors, such as insulators, such as a semi-conductor represented by Si wafer and a glass substrate, and a metal substrate, a single crystal, a non-single crystal, and all are possible, and organic materials, such as a macromolecule polymer, are also usable depending on the case.
[0054] In this invention, it is the object which offers new light-scanning equipment combining the above-mentioned actuator and the above-mentioned light source. Moreover, it is also possible by producing two or more light-scanning equipments of this invention, and operating them independently on the same semi-conductor substrate, respectively to raise the scan speed on a screen. The example of application is given below and the light-scanning equipment of this invention is explained to a detail.
[0055] <Example 1 of application> drawing 12 (a) The structure is shown in - (g) at the production approach list of the light-scanning equipment of the 1st example of application of this invention. As first shown in drawing 12 (a), after forming aluminum by 20-micrometer vacuum evaporationo as a lower electrode 202 on a single crystal (100) wafer as a substrate 201, patterning of the resist 203 is applied and carried out. The conditions of BEGINGU of a resist 203 are adjusted in that case, and the adhesion of a resist and aluminum is controlled. If it etches with the mixed liquor of the etching-reagent phosphoric acid / nitric acid / acetic acid / water of aluminum, in order that side etch may progress more quickly than the depth direction, if a resist 203 is removed, a curved surface like drawing 12 (b) will be presented, it will sleep together, and the remaining lower electrode 202 will be formed. As for the lower electrode 202, the configuration accomplishes the include angle of 30 degrees at a contact with a substrate 201 by one eighth of ellipse arcs. Next, a resist 204 is applied and dry etching performs flattening like the structure of drawing 12 (c) from the upper part. The SiNH film 205 is formed at 100 substrate temperature by the plasma-CVD method on it, and it continues, and is SiO2 as an optical waveguide layer 207 to formation and a degree by vacuum evaporationo about aluminum as the 1st electrode 206. It deposits in a spatter, and aluminum is again formed on it as the 2nd electrode 208, and, finally the SiNH film 209 is deposited at 100 substrate temperature (drawing 12 (d)). Patterning of the film of five layers deposited in drawing 12 (d) is carried out to sequence using a resist mask from a top. In etching, it is SiNH and SiO2. CF4 Dry etching and aluminum used the mixed liquor of phosphoric acid / nitric acid / acetic acid / water. The electrode for ejection is produced to coincidence in that case (drawing 12 (e)). Next, Si of a substrate 201 is etched by RIE of SF6 from a rear face, and 204f of edges of the lower electrode 202 is doubled with the etching edge of a substrate 201 (drawing 12 (f)).
[0056] After removing some up electrodes 211 of the substrate 210 separately produced to drawing 12 (b) among the processes described until now by etching about the up electrode 211 and forming 211g of crevices, etching removal of some substrates 210 is carried out, and configuration processing of a substrate 210 is performed (drawing 12 (g)). This is because lead wire can be connected to a beam 215. Then, the upper part of an insulating layer SiNH and the lower part of the up electrode 211 are joined. The approach of fixing in the location where the point of the up electrode 211 and the lower electrode 202 became a configuration like drawing 12 (g) from the exterior using the fixture about junction was used. Cutting removal of the substrate 210 of a part without the need is carried out, and it is done like

drawing 12 (g). The die length of the beam 215 of the cantilever type light-scanning equipment produced by the above-mentioned approach is [5 micrometers and the width of face of 20mm and thickness] 5mm. Moreover, spacing of the tip of a beam 215 and the lower electrode 202 was 5mm. When electrical-potential-difference 50V were added to the 1st electrode 206 and lower electrode 202, the beam 215 deformed into the configuration where the lower electrode 202 was met. Next, when the electrical potential difference was changed into the pulse and having been impressed on pulse height 80V, duty 50, and the frequency of 200Hz, the beam 215 vibrated at the 45 degrees of the maximum deflection angles to the substrate 201 and the perpendicular direction.

[0057] In the component structure of the example 1 of the <example 2 of application> application, the electrical potential difference was added by turns [of the 1st electrode, a lower electrode and the 2nd electrode, and an up electrode]. When the 1st electrode and the 2nd electrode were first dropped to the ground and it impressed on pulse height**50V, duty 50, and the frequency of 200Hz between the up electrode and the lower electrode, the beam swayed from the location of a halt of a beam to a substrate and a perpendicular direction **40 degrees to the symmetry. The light which emitted light from semiconductor laser was introduced using the optical fiber from the edge 215 of the optical waveguide part of the component of this structure. When the beam was vibrated on condition that the above, the introduced light is emitted from the point of a beam and was able to make the luminescent spot produced on the screen scan. When distance of the light source and a screen was set to 250mm, the scanning die length on a screen was 250mm.

[0058] The example of the light-scanning equipment of the type which vibrates a beam 315 in parallel to a substrate to <example 3 of application> drawing 13 is shown. Structure will be partially floated [electrodes 306 and 307 and] from the substrate 301 by the beam to which it consists of insulating layers 304 and 305 on both sides of it on both sides of the optical waveguide 308 to which the aluminum electrodes 302 and 303 are formed on the glass substrate 301, and touched it on.

[0059] A production process is shown to drawing 14 (a) - (h) (in part of XY cross section of drawing 13). After forming the 2-micrometer resist 300 as a sacrifice layer on a substrate 301 first at the pattern configuration of the operation part of a beam (drawing 14 (a)), the aluminum layer 310 with a thickness of 20micro is vapor-deposited (drawing 14 (b)). Next, an electrode configuration is produced by FOTORISO using a resist, and it considers as the aluminum electrodes 302 and 303 and electrodes 306 and 307 (drawing 14 (c)). Etching of an electrode used the dry etching of CCI4. Next, 20 micrometers of resists 311 for lift off were applied (drawing 14 (d)). Next, patterning of electrodes 302, 303, and 306 and the resists 311 other than resist 311 on 307 was carried out by the photolithography, and they were removed (drawing 14 (e)). Then, although an insulator layer is deposited in plasma CVD, in order to attach refractive-index inclination in the direction of thickness, it is SiH4 / O2 first. It is SiO2 at mixed gas. After introducing nitrogen gas after depositing 5 micrometers of film 312, and depositing 10 micrometers of SiON film 313, nitrogen gas is stopped, and it is 5-micrometer SiO2. The film 314 was deposited (drawing 14 (f)). The SiON film 313 serves as the optical waveguide 308 later shown in drawing 14 (h). Next, after lift off removed the insulator layer on the aluminum electrode 302 and 303, it covered by the resist again, the excessive insulator layer was removed by dry etching (drawing 14 (g)), and a component configuration like drawing 13 was produced. The beam 315 which melts with a solvent the resist 300 which is finally a sacrifice layer between a substrate and a beam, and has optical waveguide 308 and which can be displaced was completed (drawing 14 (h)). Next, bonding drew out to each electrode and the terminal was attached. The height of 10mm and a beam was set to 20 micrometers, and the die length of a beam set thickness to 20 micrometers. When the electrodes 306 and 307 of this component were made the ground and the sine wave of 200Hz and 100V was impressed to electrodes 303 and 302, the beam vibrated on the 75 maximum deflection squares to the substrate side and the parallel direction.

[0060] In order to introduce the <example 4 of application> light source and to make light scanning perform, the fixture shown in drawing 15 was produced and the optical fiber 520 was connected. A fixture 522 is produced to coincidence, when producing electrodes 502 and 503 in height of 20 micrometers by the product made from aluminum with a width of face [of 15mm], and a die length of 5mm. Then, for positioning of a fiber 522, according to the height and location of optical waveguide, V groove 524 is produced to a fixture, and a fiber is pasted up according to V groove 524. The micro collimator lens 525 is produced to a part for the point of a beam. The configuration of a lens was used as

the semicircle column in this example of application. The lens was produced to optical waveguide 508 and coincidence. When the light which used the halogen lamp for the light source and was introduced with the optical fiber set the light source and distance of a screen to 200mm, the scanning die length on a screen was 250mm.

[0061] The example of application to which the part of the beam of light-scanning equipment differs from the example 3 of application in <example 5 of application> drawing 16 is shown. In the part of an insulating layer, differing from the example 3 of application has arranged the insulating layer 604 on the side face of an electrode 602, and it has arranged the insulating layer 605 on the side face of an electrode 603. As an ingredient of an insulating layer, it is SiO2. It uses, and in the same process phase as optical waveguide, patterning is carried out to a desired configuration and it produces. in order to become light since there is no insulating layer in the part of a beam, and to move by this structure easily -- driver voltage -- the example 3 of application -- comparing -- 20V -- it became low.

[0062] The example of the <example 6 of application> book application is an example of the light-scanning equipment which formed at the monolithic the semiconductor laser which is the light source, and the light-scanning section on one substrate, and shows an outline to drawing 17 . the production approach -- first -- the n mold GaAs substrate 701 top -- one by one -- as a buffer layer 702 -- the n mold GaAs -- 2 micrometers and n mold aluminum0.4Ga0.6As were set to 2 micrometers as 1 micrometer and a cladding layer 703, the GaAs100A laminating of non dope GaAs100A, aluminum 0.2, and the Ga0.8As30A was set for the n mold AlGaAs to the repeat last 4 times as an active region 704, and the active region 704 of multiplex quantum well structure was formed. Next, GaAs was formed for P type aluminum0.4Ga0.8As by 0.5-micrometer molecular-beam-epitaxy method as 15 micrometers and a cap layer 706 as a cladding layer 705. Then, as it is shown in order to restrict a current impregnation region, after etching to about 0.4 micrometers of this side of a barrier layer 704, polyimide 707 was formed with the spin coat, and it etched by the crowning of an edge, and considered as the impregnation region. Next, the Cr-Au ohmic electrode was formed as a wiring electrode 708. After performing heat treatment for diffusion furthermore, a GaAs substrate is etched in order to form a resonance side. Etching is Cl2. It carried out by the RIBE method using gas. Cavity length is 300 micrometers here. Semiconductor laser was produced by the above technique. Next, the beam, the electrode for a drive, and the micro collimator lens were formed by the same approach as the example 4 of application on the same substrate. The origin on the screen which applied the electrical potential difference to the electrode and the electrode for a drive in a beam, was made to carry out the variation rate of the beam, scanned the light which came out of semiconductor laser to the single dimension, and was detached 200mm was able to be made to scan 250mm.

[0063] The same result was able to be obtained also by making the above-mentioned semiconductor laser rival with adhesives etc. on the substrate in which the light-scanning section was formed.

[0064]

[Effect of the Invention] As explained above, a poly membrane etc. can use the sufficiently small thing of a spring constant for joint material, also by the drive which needs severe actuation, it is an easy configuration and it is [the micro-actuator of this invention is excellent in endurance, and] suitable for an optical deflector.

[0065] Moreover, the optical deflector of this invention can deflect light by having separated the part and reflecting plate which receive the force, without receiving a noise with a sufficient controllability. In addition, according to the purpose of use, the direction of incidence and the reflective direction of light can also be changed, and what moreover does not affect a deflection angle is made.

[0066] Furthermore, the light-scanning equipment of this invention can offer light-scanning equipment with easy optical adjustment with a compact configuration by carrying out the variation rate of the optical waveguide in the beam of a light-scanning component for the light beam introduced from the light source produced on the same substrate as the light-scanning component produced on the substrate, or the light source placed outside.

[Translation done.]

JAPANESE [JP,06-160750,A]

CLAIMS DETAILED DESCRIPTION TECHNICAL FIELD PRIOR ART EFFECT OF THE INVENTION TECHNICAL PROBLEM MEANS OPERATION EXAMPLE DESCRIPTION OF DRAWINGS DRAWINGS

[Translation done.]

* NOTICES *

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is a perspective view explaining the 1st actuator of this invention.
[Drawing 2] (a) and (b) are the perspective views explaining actuation of the 1st actuator of this invention.
[Drawing 3] It is a perspective view explaining the optical deflector of this invention.
[Drawing 4] (a) - (f) is abbreviation production process drawing of the 1st actuator of this invention.
[Drawing 5] It is a perspective view explaining the 2nd actuator of this invention.
[Drawing 6] (a) and (b) are the plans explaining actuation of the 2nd actuator of this invention.
[Drawing 7] It is a perspective view explaining the 3rd actuator of this invention.
[Drawing 8] It is a perspective view explaining the 4th actuator of this invention.
[Drawing 9] It is a perspective view explaining the 5th actuator of this invention.
[Drawing 10] It is a perspective view explaining other optical deflectors of this invention.
[Drawing 11] It is the basic configuration perspective view of the light-scanning equipment of this invention.
[Drawing 12] (a) - (g) is the cross-sectional view showing the process of the light-scanning equipment by the examples 1 and 2 of application of this invention.
[Drawing 13] It is the perspective view of the light-scanning equipment by the example 3 of application of this invention.
[Drawing 14] (a) - (h) is drawing showing the process of the light-scanning equipment by the example 3 of application of this invention.
[Drawing 15] It is the perspective view of the light-scanning equipment by the example 4 of application of this invention.
[Drawing 16] It is the perspective view of the light-scanning equipment by the example 5 of application of this invention.
[Drawing 17] It is the perspective view of the light-scanning equipment by the example 6 of application of this invention.
[Drawing 18] It is the perspective view of the conventional optical deflector.
[Drawing 19] It is the schematic diagram showing the configuration of conventional light-scanning equipment.
[Description of Notations]
11 41 Fixed electrode
12, 22, 42, 55, 62, 72 Movable electrode
13,131 49,491 Supporting beam
63 71 Drive plate
14, 15, 43, 44,
64, 65, 73, 74, 81 Driven plate
16, 45, 66, 75 Support plate
17, 18, 19,
46, 47, 48,
67, 68, 69,
76, 77, 78 Joint

31 Silicon Substrate
32 Thermal Oxidation Film
33 Silicon Nitride
34 Contact Hole
35 Polish Recon Film (Electric Shielding Layer)
36 Silicon Oxide (Sacrifice Layer)
37 Polish Recon Film
82 Reflecting Plate
83 Incident Light
102, 103, 202, 211, 206,
208, 302, 303, 306, 307 Electrode
101, 205, 209, 304, 305 Insulating layer
104, 207, 308 Optical waveguide
105 Cantilever
215 315 Beam
201, 210, 301 Substrate

[Translation done.]

* NOTICES *

CLAIMS

[Claim(s)]
[Claim 1] A mechanical component which consists of a fixed electrode and a movable electrode, and at least two driven sections to which an end was connected at joint by which fixed support was carried out, It is the micro-actuator with which it has joint which connects said mechanical component and said driven section, and said driven section carries out bending actuation repeatedly in a part of said joint. Said mechanical component is what drives said driven section according to electrostatic force generated by impressing an electrical potential difference between said fixed electrodes and said movable electrodes. Said driven section A micro-actuator characterized by being that from which the direction of force generated in said mechanical component and the direction of a variation rate of the driven section concerned differ.
[Claim 2] A micro-actuator according to claim 1 characterized by accumulating said mechanical component and the driven section into the same substrate.
[Claim 3] A micro-actuator according to claim 2 with which the direction of force generated in said mechanical component is characterized by being parallel displacement in a substrate side.
[Claim 4] A micro-actuator according to claim 2 with which the direction of force generated in said mechanical component is characterized by being the direction of the substrate side internal version.
[Claim 5] Said joint is a micro-actuator according to claim 1 characterized by changing with a metal thin film.
[Claim 6] Said joint is a micro-actuator according to claim 1 characterized by changing by poly membrane.
[Claim 7] Said joint is a micro-actuator according to claim 1 characterized by changing with a ceramic thin film.
[Claim 8] Said joint is a micro-actuator according to claim 1 characterized by changing with a superelastic thin film.
[Claim 9] An optical deflector characterized by making light which has a micro-actuator according to claim 1, equipped at least one place of the driven section of this micro-actuator with a reflector, and irradiated this reflector scan.
[Claim 10] Said reflector is an optical deflector according to claim 9 characterized by changing by metal membrane.
[Claim 11] Said reflector is an optical deflector according to claim 10 characterized by changing with metal vacuum evaporationo film.
[Claim 12] Said reflector is an optical deflector according to claim 10 characterized by changing with metal plating film.
[Claim 13] Said reflector is an optical deflector according to claim 10 characterized by changing with a single crystal metal thin film.
[Claim 14] Said reflector is an optical deflector according to claim 13 characterized by changing with a liquid phase epitaxy single crystal metal thin film.
[Claim 15] It has the 1st electric conduction field which has optical waveguide and conductivity in a cantilever of a thin film configuration. The 2nd electric conduction field which has an insulating region in said cantilever near [said] the waveguide, and has conductivity across this insulating region is arranged. According to electrostatic force produced between the 1st electric conduction field in said cantilever, and the 2nd electric conduction field, and elastic force which said cantilever restores from

deformation Light-scanning equipment characterized by moving a light beam introduced into optical waveguide arranged in said cantilever from the light source arranged at a root of said cantilever by moving a cantilever of a thin film configuration in accordance with a configuration of structure including the 2nd electric conduction field.
[Claim 16] Light-scanning equipment according to claim 15 characterized by having two structures including said 2nd electric conduction field, and these confronting each other on both sides of said cantilever.
[Claim 17] Light-scanning equipment according to claim 15 with which electrostatic force produced between the 1st electric conduction field in said cantilever and the 2nd electric conduction field is characterized by working effectively gradually from a part of a root of this cantilever.
[Claim 18] Light-scanning equipment according to claim 15 with which electrostatic force produced between the 1st electric conduction field in said cantilever and the 2nd electric conduction field is characterized by making it generated by applying an electrical potential difference to two electrodes.
[Claim 19] Light-scanning equipment according to claim 15 characterized by said the 1st some or all of an electric conduction field consisting of a semiconductor material.
[Claim 20] Light-scanning equipment according to claim 15 with which electrostatic force produced between the 1st electric conduction field in said cantilever and the 2nd electric conduction field is characterized by applying an electrical potential difference to the 2nd electric conduction field.

[Translation done.]